Grand Avenue Viaduct
Carrying traffic on West Wisconsin Avenue over the Menomonee River Valley, North 44th Street, and the Chicago, Milwaukee & St. Paul Railway
Milwaukee
Milwaukee County
Wisconsin

HAER No. WI-27

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WIS,
40-MILWA,
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

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HISTORIC AMERICAN ENGINEERING RECORD

Grand Avenue Viaduct
(Wisconsin Avenue Viaduct)

Location:	Carrying traffic on West Wisconsin Avenue, over the Menomonee River Valley, North 44th Street, and the Chicago, Milwaukee & St. Paul Railway. Milwaukee, Milwaukee County, Wisconsin UTM: 16.421380.4765350 Quad: Milwaukee, Wisconsin
Dates of Construction:	1907-1911
Present Owner:	City of Milwaukee
Present Use:	Vehicular and pedestrian bridge
Significance:	The Grand Avenue Viaduct, Milwaukee's earliest example of a large scale concrete bridge, was the result of a national design competition which included entries from some of the most prominent architects and engineers of the day. The winning entry by The Concrete-Steel Engineering Company and by Palmer & Hornbostel of New York employed the Melan steel beam reinforcement method. The Art Deco bridge is of a barrel arch design and is a relatively late example of the Melan system. Second place in the competition went to a more innovative ribbed arch design by the well-known concrete engineer, C. A. P. Turner. City officials envisioned the viaduct as one link in a grand boulevard that would eventually connect Milwaukee with Madison, 100 miles to the west.
Historian:	Edwin Cordes Wisconsin Historic Bridges Recording Project Summer 1987

HISTORY

The Grand Avenue Viaduct, which carries traffic from West Wisconsin Avenue across the Menomomee River Valley, was one of Wisconsin's earlieet and most important large concrete viaducts. The bridge's visionary link to the state capitol in Madison, spurred the further development of suburban Milwaukee and Wauwatosa. The final design was selected through a national competition in 1907, and the bridge was formally opened to traffic four years later on July 4, 1911. The entrants included some of the more prominent concrete engineers and architecte of the time. A contemporary description of the bridge publiehed by the cement contractor calle the epan one of the world'e most noteworthy structures. This report claimed the viaduct to be "the longeet concrete example in the world and a feat of engineering that will not be eclipeed in either beauty or size for many years to come."[1]

DESCRIPTION

The Grand Avenue Viaduct, built in 1911, has undergone exteneive renovation since its completion. Work done on the bridge in both the 1930s and the 1950s removed a majority of the decorative details. The form, etructural integrity and aesthetics of the bridge remain however.[2] Eight reinforced concrete, open spandrel arches span a distance of more 1,500 feet and carry a deck 70 feet wide. Each of the eight major arches has a span of 145 feet and a maximum riee of 28 feet. Two filled epandrel 60- and 80-foot arches frame each end of the viaduct.

The span originally included an ornamental, cast in place, scroll design balustrade and decorate lamp standarde. Two lamps were located above each pier, along with one above the arch's crown. Both the lamps and the balustrade contained elements of Art Deco styling. Simplietic decorative copings in a medallion pattern once surrounded the piers at the springing point of the arches. Molded panels signified the crown of the arch and enclosed the spandrel walls above the piers.[3] All the decorative elements were removed by 1951, the city completed a large resurfacing and concrete repair project.

The piers, which are 14 feet thick at the base, are divided into three parts below the barrel vault skewbacks by two arched openings, 15 feet wide and 30 feet high. This was done in order to reduce the massiveness of the structure. The arches spring from the piers at a height which allows the span lengths to remain the same even with the variations of the ground level.[4] The piers themselves were not massive enough to resist the outward thrust of the archee, so care was taken in construction to pour all the arches simultaneously, thereby balancing the load.[5] A stiff clay eubsoil allowed the limeetone foundations of the piers to be placed without going down to the rock stratum. Engineers took sample boringe both before and during conetruction to insure eafety.[6]

The barrel arches are reinforced, using a contemporary method called the Melan system, named after its inventor. Large I-beams spaced three feet on center are bent to approximate the shape of the arch and the encased in a continuous pour of cement. Structurally, the arch functions like a steel structure with a concrete coat.[7] The transverse spandrel walls and decking are reinforced, using Thacher reinforcing bars.[8] A total of 650 tons of steel reinforcing bars and 270 tons of structural steel were used in the viaduct's construction.

The arches, which are two feet six inches at the crown, increase to six feet radially at the skewback point. The transverse spandrel walls above the arches are spaced 10 feet, 6 inches on center. Thirty feet to either side of the crown is of filled spandrel design. A reinforced concrete floor slab rests on the transverse supports and contains four expansion joints per span.[9]

The Grand Avenue Viaduct was originally envisioned as the first link of a grand boulevard that would eventually stretch from downtown Milwaukee to the state capitol in Madison, approximately 100 miles to the west. The street was to be lined with magnificent mansions and places of worship.[10] Prior to the construction of the viaduct, Grand Avenue (now called Wisconsin Avenue), east of the Menomonee River Valley, had become one of the city's most opulent addresses. although the grandiose plans were never realized, the area west of the viaduct eventually became one of the city's more desirable residential areas, and the viaduct promoted further suburban development in the village of Wauwatosa.

While the Menomonee River Valley presented a barrier to those who hoped to develop the city westward, it provided a place of residence for many of the area's blue collar workers. The area directly below the viaduct has been known since the 1890s as either Pigstown or Pigsville. The origin of the neighborhood's name is still unsure. Some people attribute the name to a local stagecoach tavern owner named George Pigg. Others believe the name can be traced to a local farmer named Fries, who raised a large number of pigs in the area.[11]

The two largest ethnic groups found in the valley were the Germans and the Slavs. There were also significant numbers of Serbs, Czechs, Poles and Russians. The people of Pigsville were primarily laborers and tradesmen working in the local valley breweries or foundries. The area also contained a large number of taverns and restaurants. Although the area residents constantly petitioned for annexation by the city of Milwaukee, it did not occur until well after the bridge was completed in 1925.[12]

DESIGN COMPETITION

The first mention of a viaduct across the Menomonee River Valley at this point was a proposal by Samuel R. Bell, a Civil War veteran and county supervisor, who made his plea to the county in 1899. Bell, the owner of a local insurance agency, was a member of the county's Highway and Bridges Committee. The supervisor's dream was originally rejected because of the tremendous cost involved. In 1903, the County Board passed a resolution permitting the sale of a bond iseue for construction of the viaduct. Bell lobbied for support and, on January 5, 1904, the issue passed on a 26 to 12 vote. A formal competition, opsn to all qualified designers, was arranged, in order to achieve the most appropriate design.[13]

On Auguet 10, 1906, the Milwaukee County Clerk officially opened the Grand Avsnue Viaduct Design Competition, inviting all interested partiss to submit their ideas. Specifications for the span stated that it must be of reinforced concrete for longevity and located on the previously-chosen site, carrying traffic from Wisconsin Avenue (then callsd Grand Avenue) across the Menomonee River Valley. The invitation also stated that all qualified dssigns would be publicly displayed for six days, after which a winner would be selected and prize money distributed. First prize was worth $1,500, second and third place prizee were valued at $1,000. All schemes became the property of Milwaukee County.

Competition specifications also stated that the total cost of the bridge could not exceed $400,000. The width of both the roadway and sidewalks was specified in ordsr to allow for both automotive and electric streetcar traffic. Clearance was to be maintained over the Chicago, Milwaukee and St. Paul Railroad and local streets in the valley. A final requirement stated that neither three dimensional nor color rendered drawinge were acceptable.[14]

The Milwaukee Joint Committee on Highways, Bridges, Laws, and Legislation appointed a board composed of distinguished engineers to aid the committee in crsating the program and choosing ths winner. The board consisted of Professor Frederick E. Turneaure of Madison, Wisconsin, Ralph Modjeski of Chicago and Gustav Steinhagen of Milwaukse. The members, while relatively unknown at the time, all achieved some level of recognition later in their lives and merit further discussion later.[15]

The competition closed on October 15th of that year, with 12 submissions. After the designs were displayed for the public, first prize was awarded to The Concrete-Steel Engineering Company of New York, in conjunction with Palmer and Hornbostel Architects. Their scheme for a concrete bridge, reinforced with the Melan system, was entered undsr the 'nom de plume" M. V. M.. Second place, according to the majority report, went to a Minneapolis collaboration appearing under the initials T. K. C.. This team consisted of C. A. P. Turner, a well known concrete engineer, and Kees & Colburn Architects. Charles F. Class of Trenton, New Jersey, wae awarded an honorable mention for his design submitted under the title 'A. N. Ingenieur.' The committee felt that this design did not sufficiently conform to the program's requirements to qualify for the third place cash prize.[16]

T. K. C.'s second place design employsd a numbsr of innovative features in its construction. Isolated ribs were used in ths arches rathsr than a barrel vault. The reinforcing was composed of a helix of steel rods according to the method originated by Armand Considere' in France. Unlike the winning entry, this design did not contain any expansion joints but absorbed the temperaturs variations in the elasticity of the material. The committse called this entry a "rather bold design" which was "in advance of the current American practice." The skepticism of the board to the new Europsan innovations probably caused this design not to win.[17]

The second place award was notable not only because it involved a novel design, but because it associatsd with the well-known Minneapolis engineer, Claude A. P. Turner. The engineer is associated with the development of the concrete flat slab construction method in the United States and was granted a patent for his innovations in 1908.[18] Flat slab construction made possible ths erection of large warehouse-type buildings requiring overhead space and hsavy loading capacities. Flat slab design was first applied to bridge construction in 1909 when Thomas Greene chose this method for the Lafayette Avsnue Bridge over the Soo Line tracks in Minneapolis. This type of construction was advantageous in situations which required restricted overhead clsarance because it eliminated thick girdsrs.[19]

C. A. P. Turner is also known for his dssign of a steel, three-hinged railroad bridge for the Soo Lins, over the St. Croix River near New Richmond, Wisconsin. The delicate rib arch span is remarkable for its ability to carry the hsavy railway loads.[20] The engineer received the commission for the Highland Boulevard Viaduct in Milwaukee two years after the Grand Avenue Viaduct competition. Located northeast of the Grand Avenue Viaduct, this concrete reinforced, barrel arch span over the Chicago, Milwaukee & St. Paul Railway tracks employed hooped steel rods for its tensile strength, and shows that at the tims of ths Grand Avenue's construction, concrete reinforcing was undsrgoing a revolution.[21]

Many of the remaining designs did not qualify for final judging becauss they varied significantly from the competition requirements. The primary reason for disqualification was the length of the structure. Many schemes attempted to cross the valley at a different site, failing to provide for a proper alignment. Many also exceeded the $400,000 limit. One example, an ornate Gothic structure, had an estimated cost of over $528,000. Other designs included concrete arches without reinforcing, three-hinged, reinforced arches, and archss with clear spans exceeding 300 feet. One of the most interesting designs was called "the Base-ball viaduct," because it contained elaborate cast athlstic statues attached to ths piers.[22]

DESIGN BOARD

The special board appointed to oversee the viaduct design competition was composed of three engineers who all made important contributions to their field. Ralph Modjeski, a civil engineer from Chicago, who later designed numerous large scale suspension bridges. Modjeski's Burlington Railroad Bridge, built between 1914 and 1917 across the Ohio River at Metropolis, Illinois, spans nearly 3,500 feet. The seven Pratt truss spans achieved a maximum record length of 723 feet. Modjeski designed a huge cantilever bridge over the St. Lawrence River at Quebec in 1911 and used an innovative K truss for wind bracing. The engineer also served as a consultant on the construction of the enormous San Francisco Bay Bridge.[23]

Gustav Steinhagen, a German-born immigrant, worked as a civil engineer with Washington Roebling on the Brooklyn Bridge. Steinhagen was also responsible for the design of the Wells Street Trolley Viaduct, built in Milwaukee in 1892. Mr. Steinhagen also functioned as the supervising engineer on the Grand Avenue Viaduct and as consulting engineer for many other city projects.[24]

The third board member, F. E. Turneaure, was a locally-known civil engineer. After receiving his degree in civil engineering from Cornell University in 1889, he accepted a position at the University of Wisconsin as professor of bridge and sanitary engineering. In 1902, Turneaure became acting dean of the College of Mechanics and Engineering, a position he held until 1937. He also served as the city engineer for Madison from 1900-1902. The engineer was also known for his writings, including Modern Framed Structures, a book dealing with the construction and aesthetics of bridges, which he co-authored.[25]

BRIDGE CONSTRUCTION

The construction of the Grand Avenue Viaduct was a very complex and large scale endeavor. The size of the span, as well as its concrete construction, necessitated the erection of a complete contractor's plant on the site. Storage facilities were needed to hold not only the enormous amounts of raw materials involved in mixing the concrete, but also the lumber required for falsework and the steel reinforcing. Railroad lines in the valley provided a convenient method for receiving these items.

The contract for the viaduct's construction, as written by the city, was quite specific in all its details. Exacting standards were to be maintained throughout the project by the scrutiny of expert inspectors. All materials involved in the mixing of the concrete were to arrive at the site at least twenty days in advance, so that they could be tested before processing. An on-site laboratory built by the contractor was used to examine the different ingredients in the high grade Portland cement. specific grades and mixtures of cement were required for different parts of the bridge. The contract stated that a continuous pour must be used for the arches. Each layer was to be "rammed" to remove excessive moisture and the next layer poured before the previous one had set. Work was to progress continuously 'day and night' to complete each longitudinal section.[26]

Before concrete work could begin, limestone foundations for the piers were laid. Piles were driven to support the falsework and carpenters were hired to construct the centering and falsework. The initial contractor, Newton Engineering Company of Milwaukee, used the central plant construction method. A large cement mixing plant was located near the railroad side track in the valley. All of the cement was mixed in a large Smith mixer. Above the mixer were two measured bine, one containing sand and the other containing gravel. Small dump cars conveyed the concrete to the desired point, using narrow gauge tracks. The cars could discharge directly into the excavation for foundation work. Pier construction required the use of a derrick and bottom dump bucket to hoiet the materials.[27]

Soon after the project began, disputes began to arise between Gustav Steinhagen, who functioned as the supervising engineer for the county, and the construction company. Newton Conetruction Company refused to follow the engineer'e orders, calling them 'arbitrary and unreasonable.' Steinhagen felt that the contractor had not employed enough men to complete the bridge in two years. A grievance hearing was held and the investigating committee decided in Steinhagen's favor. Newton Construction Company was released from their contract in September 1908.[28]

The National Engineering and Construction Company wae formed by a number of local contractors specifically to complete the viaduct project. Gustav Kahn and J. A. Messiroff eerved as chief engineers for the company. The company abandoned Newton's central plant method and instead erected eeveral smaller mixing stations. In this method, raw materials were hauled rather than the mixed concrete. Sand and gravel was conveyed to the emaller Smith mixers in measured wheelbarrowe. Large towers with steep runways provided a method to direct the flow of concrete. The mixed concrete was then hoisted to a hopper located atop one of the many towers, using a gae-powered winch. Spouts at the ends of the slides directed the concrete where it was needed. Care was taken in the mixing to prevent large clumps which would clog the narrow shoots.[29] This method helped insure a continuoue pour for the arches.

Because of a labor shortage. The Newton Construction Company imported non-union Black workers from Tennessee. Working during the night to remain as inconspicuous as possible, the workers would tamp down the concrete being poured into the large wooded pier forms in rhythm while singing spirituals.[30] Before National Engineering and Construction took over the contract, a clause was entered, allowing only union labor to be used. The following pay scales were put into effect:[31]

General Laborers	\$ .15 per hour
General Handymen	\$ .25 per hour
Craftsmen and Carpenters	\$ .38 per hour

The following is an approximate quantity of materials used in construction:[32]

Marquette Portland Cement	55,000 barrels
Steel reinforcing bars	650 tons
Structural steel	270 tons
Piling	72,000 feet
Lumber	3,000,000 feet
Concrete	45,000 cubic yards
Crushed stone	36,000 cubic yards
Sand	20,000 cubic yards
Excavation	20,000 cubic yards
Earth fill	20,000 cubic yards

The total cost of the viaduct well exceeded the \$400,000 competition limit and included a claim paid to the Newton Engineering Company of over \$67,000 for work it was not reimbursed for originally. Total cost has been estimated to be in excess of half a million dollars.[33]

THE MELAN SYSTEM

The winning design employed what was considered a fairly typical method of concrete reinforcement construction. The Melan system which was patented in September 1893 was named for its inventor, Joseph Melan (patent number 505,054).[34] This system of reinforcement consisted of large steel I-beams bent to approximate the shape of the arch and placed in parallel series near the concrete's under surface. The concrete not only provided the compressive strength, but also protected the steel from corrosion. Melan believed his innovation provided a fireproof arch which had a greater strength to weight ratio than the systems previously used. Construction time and cost could be reduced using this system, because neither bolting nor riveting of the beams was required at the site.[35]

Melan's system was first applied in 1894 to a small highway span in Rock Rapids, Iowa. A typical example of this reinforcing method can also be seen in the Franklin bridge in Forest Park, St. Louis, built in 1898. Many engineers, including Fritz von Emperger, made later improvements to the system, but Melan's basic design was to remain one of the more common forms of concrete reinforcement until the steel rod and deck-girder methods of construction became accepted.[36]

The initial agreement for the Grand Avenue Viaduct specified that three percent of the total contract price was to be paid in royalty charges for use of the Melan system. The Concrete-Steel Engineering Company, the winning designers, owned the patent rights to this system. This company also owned the patent rights to many other early concrete reinforcing systems, including methods originated by Thacher, Von Emperger and Mueser. The Concrete-Steel Engineering Company was the successor to the Melan Arch Construction Company and was headed by Edwin Thacher and William Mueser.[37]

FOOTNOTES

1 "An Industrial and Architectural Achievement - Being A Brief Description of the Grand Avenue Viaduct," a booklet printed by the Marquette Cement Manufacturing Company of LaSalle, Illinois, celebrating their involvement in the project. A copy can be found at the Milwaukee County Historical Society.

2 "Specifications for Repair and Alteration od the Wisconsin Avenue Viaduct," the city of Milwaukee Department of Public Works - Bureau of Bridges and Public Buildings - 1939, 1950-51, 1953.

3 Original ink-on-linen copies of the 1907 Concrete-Steel Engineering Company drawings titled "Concrete Steel Arch Viaduct - Melan System - Over the Menomomee Valley at Grand Avenue, Milwaukee, Wis." Drawings can be found at the Bureau of Bridges and Public Buildings, Milwaukee, Wisconsin.

4 "Competitive Designs For a Reinforced-Concrete Viaduct in Milwaukee, Wis.," Engineering News, Vol. 57, No. 7, February 14, 1907, pp. 178-181.

5 Ibid.

6 "Milwaukee's Concrete Viaduct," Municipal Journal, Vol. 33, No. 18, October 31, 1912, pp. 631-634.

7 Carl W. Condit, American Building (Chicago and London: The University of Chicago Press, 1982), p. 174.

8 "Concrete Steel Arch Viaduct." Drawings.

9 "Early Construction Methods On The Grand Avenue Viaduct," The Engineering Record, Vol. 59, No. 21, May 22, 1909, pp. 655-656.

10 Ibid. p. 631.

11 Built in Milwaukee - An Architectural View of the City (Milwaukee: City of Milwaukee Department of City Development Publications, 1983), p. 169. An architectural survey of the city completed by Landscape Research, Inc. for the city of Milwaukee mayor's office.

12 Ibid.

13 "Viaduct Had Its Birth Amidst A Battle," The Milwaukee Journal, March 5, 1950.

14 "The First Prize Design for the Grand Ave. Viaduct, Milwaukee," The Engineering Record, Vol. 55, No. 6, February 9, 1907, pp. 150-151.

15 Ibid.

16 Ibid.

17 "Competitive Designs," p. 180.

18 American Building, p. 243-244.

19 Ibid., p. 259.

20 Ibid.

21 "The Highland Boulevard Viaduct, Milwaukee," The Engineering Record, Vol. 59, No. 24, June 22, 1909, pp. 747-748.

22 "First Prize Design," p. 151.

23 American Building, p. 214. 224. 237.

24 "Milwaukee's Concrete Viaduct," p. 631.

25 L. W. Murphy and J. G. Crownhart, Who's Who at Wisconsin - Volume 1 (Madison, Wisconsin: White Spades Company, 1920), p. 78.

26 "General Specifications for a Concrete Steel Arch Viaduct - Melan System - Menomonee Valley, Milwaukee, Wisconsin." A copy of the original contract specifications can be found at the Bureau of Bridges and Public Buildings, Milwaukee, Wisconsin.

27 "Milwaukee's Concrete Viaduct," p. 632.

28 "Viaduct Had Its Birth Amidst Battle."

29 "Milwaukee's Concrete Viaduct," p. 633.

30 "Viaduct Had Its Birth Amidst Battle."

31 Ibid.

32 "Milwaukee's Concrete Viaduct," p. 634.

33 Ibid.

34 Joseph Melan, "United States Patent Application #505,054 - A Vault for Ceilings, Bridges, patented September 12, 1893.

35 Ibid.

36 American Building, p. 175.

37 "Contract Specifications."

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